NORTON SOUND WEIR SITE INVESTIGATIONS

By

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ABSTRACT

Todd, G. L. 2003. Norton Sound Weir Site Investigations. Alaska Department of Fish and Game, Commercial Fisheries Division, Regional Information Report No. 3A03-19, Anchorage.

Although results for some river systems were previously reported (Menard 2001), pertinent data/results are included in this report to combine all surveyed rivers and corresponding data in one document. In 2001, ten rivers were surveyed in the Southern Seward Peninsula area to locate and assess site feasibility for placement of resistance-board "floating" weirs to enumerate adult salmon returns. During 2002, further site assessments were conducted on the Pilgrim and Unalakleet Rivers, and two sites were examined on Shaktoolik River. The Pilgrim River site was finalized and approved. A resistance-board weir was fabricated and will be installed and operated in 2003. Pilgrim River was selected for the first resistance-board weir in Norton Sound because of favorable site survey rating, limited escapement data, and unreliable tower counts for prior years.

At surveyed resistance-board weir locations, pertinent hydrologic data including flow, depth, and width were measured and recorded and bottom substrate classified. Ratings were assigned to each site based on hydrologic conditions, substrate types, and on probable successful operation of a weir. Weir costs are estimated at $160/ft plus $7,000 for a live box sampling trap and bulkheads. Additionally, $41,000 (approximate) in labor and other fixed costs would need to be added to each weir's cost and transportation costs from the fabrication location (Nome) to the selected river weir site.

INTRODUCTION

Norton Sound Salmon Management District includes all waters between the latitude of Point Romanof (southern boundary near the village of Stebbins) and latitude of Cape Douglas (northern boundary), which is northwest of the Sinuk River mouth. This district includes six commercial salmon fishing subdistricts and numerous anadromous streams (Figure 1). Port Clarence District includes all waters between the latitude of Cape Douglas and latitude of the western most tip of Cape Prince of Wales (northern boundary). Current salmonid enumeration programs operated by the Alaska Department of Fish and Game (ADF&G) in these districts include two counting towers, one weir and one test fish project. Additionally, four counting tower projects are operated by cooperating agencies, Kawerak Inc. (three) and Unalakleet IRA council (one); one weir project is operated by the U.S. Bureau of Land Management. Department personnel also conduct numerous inseason aerial surveys on selected district rivers to monitor adult salmon escapements and assess run timing.

Norton Sound harvest management can benefit from improvements to existing programs for the collection of catch and escapement data (NSRR STC 2002). Examples of improvements are conversion of existing tower or aerial survey assessments to weir based programs for enumeration of chum *Oncorhynchus keta*, sockeye *O. nerka*, or coho *O. kisutch* salmon escapements. Proposed projects should be based on recommendations from the Norton Sound Weir Site Investigation Studies of 2001 (Menard 2001) and additional 2002 studies.

Escapement estimates vary in accuracy by project and type of assessment. Although aerial surveys are the least accurate method, they allow for a greater number of river systems to be assessed economically than do other types of escapement projects. Counting tower assessments are more accurate than aerial surveys but are still estimates and are often constrained by an accompanying difficulty in capturing salmon for age, sex, and length (ASL) sampling and consistent visibility for counting. Weirs are the most accurate method because all fish are counted that pass through the structure and fish are easily trapped for sampling. The most effective weirs to operate are resistance-board, also known as "floating", weirs. Although initial costs are higher, the advantage of resistance-board weirs is that once installed they can withstand higher water flows. If the water flow exceeds the limit of a resistance-board weir, the structure does not wash out as conventional picket and panel weirs do, but will slip below the water surface and then re-float when water levels subside. This flexibility results in less maintenance by the crew, less counting time lost, accurate enumeration by species, and the ability to randomly sample fish as they swim through the weir.

Resistance-board weirs operate most effectively in rivers of moderate water depth (1-1.5 m) with an even bottom profile (approximately level), with sufficient sized gravel/cobble substrate for anchoring the weir to prevent scouring and possible wash out, and with a maximum flow of less than 15 cubic feet per second (ft^3/s) at any point; depending on debris loading and other factors, flows greater than 15 ft^3/s are likely to cause resistance board weir sections to sink.

Pilgrim River drains into Port Clarence District, and this river has the largest sockeye salmon run in the Norton Sound area (Figure 1). With road access from Nome, fishing effort on this river appears to be increasing, likely because of continuing fishing restrictions in Nome Subdistrict. Salmon Lake forms the headwaters of Pilgrim River where a five-year fertilization project was conducted to increase food production for juvenile salmon (Todd and Kyle 1996, 1997; Todd *In Press*). A counting tower has been operational some years, but has only been successful in 2000 and 2002 because of turbid water and problems differentiating chum and sockeye salmon (Rob 1999, Kohler and Knuepfer 2001).

Unalakleet River (Subdistrict 6) is the largest producer of salmon, especially chum and chinook *O. tshawytscha* salmon, in Norton Sound. It also supports the largest and only ongoing commercial fishery in the District, most recently for coho salmon. Sport fishing has increased, mainly for chinook salmon during the last decade. Test gill netting has been conducted yearly in the lower Unalakleet River since 1981 (Kohler 2002). Gillnet catches are used as an index to assess run strength, timing, and for the collection of salmon for ASL sampling. Inriver subsistence surveys (inseason) and aerial surveys are also used to assess salmon escapements.

During the last six years, a counting tower program has operated on the North River, the largest tributary of the Unalakleet River. Tower counts are used to monitor salmon escapements and assess run strength and timing (Kohler and Knuepfer 2001). This river is considered a significant component of the Unalakleet River chinook salmon stock grouping (Wuttig 1998, 1999), but a minor component of the Unalakleet chum salmon stock grouping and its relative contribution to the coho salmon run is unknown. Coho salmon counts are often interrupted because of turbidity during high water conditions common in the fall, which also affect the success of aerial survey assessments drainage wide.

Shaktoolik (Subdistrict 5) commercial fisheries share a common boundary with Subdistrict 6 (Unalakleet), so management actions are applied to both subdistricts. Interceptions occur in the adjoining subdistrict, so reliable salmon counts are needed for effective inseason management for commercial and subsistence fisheries by drainage. Tannic staining and high water events preclude accurate aerial surveys counts in the Shaktoolik River drainage most years. A counting tower was operated for three years, but was discontinued because high water and turbid conditions prevented accurate counts by species.

METHODS

Rob Stewart, an ADF&G Fish & Wildlife Technician IV, conducted site assessment surveys. Mr. Stewart has done numerous site surveys for possible resistance-board weir locations on tributaries of the Yukon and Kuskokwim Rivers, and has fabricated eight resistance-board weirs (Stewart 2002). Fishery technicians and biologists from ADF&G, Kawerak Inc., and Bering Sea Fishermen's Association (BSFA) assisted Mr. Stewart during these site surveys.

Survey crews used an outboard jet unit powered riverboat to access the rivers and look for potential sites. At potential weir sites the crews measured and recorded pertinent hydrologic data including flow, depth, width, substrate type, and location. Locations were determined with a hand held Global Positioning System (GPS) to within 100 meters accuracy. Local landmarks near sites were also noted and recorded. River widths were measured with a tape measure, stretched perpendicular across the river flow from river edge to the opposite edge. A *Scientific Instruments* Model 1210, Price-type current meter with Model 9000 digital display was used to measure the water flow velocity at various points along the measured axis. Depths were recorded from the flow meter staff gauge. Velocity, depth, and station width (river subsections) were entered into a spreadsheet to calculate the total flow, which is reported as cubic feet per second. At sites rated poor to fair because of presence of less desirable substrate materials, substrate sizes, or soft mud banks, only depth and current measurements (velocity) were taken at a few locations across the main river channel.

River bank and bottom substrate observations were made at the potential sites, and recorded as sand (smaller than 3/8 inch), gravel (larger than 3/8 in and less than small size fist), small to large cobble (larger than small size fist), or bedrock. Rob Stewart visually determined substrate classification types and sizes; materials were not actually measured or sieved. Sand substrates tend to be poor for anchoring resistance-board weirs and increase the potential for washouts and scouring underneath the weir more than other types of substrate. Mixed gravel and small cobble is the preferred substrate for anchoring resistance-board weirs. Bedrock and large cobble/boulder substrates are usually not even enough for the anchor rail to lie flat along the bottom to form a fish tight barrier.

Ratings were assigned (poor to very good) to each surveyed site by Rob Stewart, and were dependent upon probable successful operations of a resistance-board weir as determined by the velocity, depth and substrate characteristics. Total costs of fabricating a weir and logistics of transporting the weir to the site were not factored into the rating process. Cost estimates for a resistance-board weir were calculated by multiplying the width of the river at the selected site by $160/foot FOB (free on board) Nome (estimated weir material cost). Included in each site cost is $7,000 to build a live box (sampling) trap and bulkheads. Additional costs incurred would be startup costs for tools and equipment (approximately $4,000), warehouse rental for fabrication/assembly, approximately $30,000 in personnel costs for fabrication, and transportation of finished weir sections and other parts and equipment to the selected site.

RESULTS

During 2001, 23 potential resistance-board weir sites were examined on ten different river systems draining into Norton Sound and Port Clarence. Very good site ratings were assigned to sites on four of the rivers: Tubutulik, Kwiniuk, Sinuk, and Niukluk Rivers (Table 1). Additional rivers surveyed in 2001 included Pilgrim, Nome, Eldorado, Snake, Unalakleet, and North (Menard 2001).

In late July to early August 2002, further site assessments were conducted on the Unalakleet (two sites) and Pilgrim Rivers (one site). Several sites on the Shaktoolik River were also surveyed. Further work needs to be done before the Unalakleet River is approved, which will be contingent upon public acceptance for the selected location, involvement of additional cooperators in fabrication and operations, and commitments for long term funding.

Unalakleet River

Two Unalakleet River sites were examined during 2001, and one site (Site 3) was examined in 2002. Site 1 was estimated to be approximately 20 km from Unalakleet and was rated as good, even though the water was too high at the time for measuring depth profile and discharge. This site may be suitable in normal lower water conditions. Turbidity may be a problem on Unalakleet River during high water years. Site 2 near Sarren's camp was recommended to the crew because of its shallowness. However, this site was rated poor because during low water conditions the site may become too shallow to effectively pass fish and the bottom was unstable, which would lead to scour if a weir was installed. During 2002, measured depths at Site 3 averaged 1.5 ft with a maximum of 2.5 ft. (Table 1). Recorded velocities were 1.9 feet per second (ft/s) average, 2.9 ft/s maximum, and maximum point flow was 6.7 ft/s. Discharge was estimated at 979 ft^3/s. River width was 325 ft and therefore estimated weir material costs were $59,000.

Pilgrim River

Pilgrim River Site 2 was rated good during 2001, and was approved for resistance-board weir installation after additional examination in July 2002 because of favorable hydrologic and substrate characteristics. The site is located approximately 10 km upriver from the Pilgrim Hot Springs and 10 km downriver from the Kougarok Road Bridge (Figure 1). River width at Site 2 is 220 ft and estimated weir costs were $42,040. Hydrologic measurements were: water depth 2.3 ft average and 3.2 ft maximum, velocity 2.1 ft/s average and 3.1 ft/s maximum, maximum point flow was 10.1 ft/s, and estimated discharge was 1,305 ft^3/s (Table 1).

Shaktoolik River

Two sites on the Shaktoolik River were surveyed on 23 July, 2003. Site 2 was rated fair/good because of mud banks although the bottom substrate was mixed gravel (Table 1). Site 1 was rated good and the bottom substrate was packed mixed to large gravel. Estimated weir costs for a 200 ft weir at this site were $39,000. Measured hydrologic conditions were: depth 2.3 ft average and 3.2 ft maximum, velocity 1.5 ft/s average and 2.6 ft/s maximum, maximum point flow was 8.5 ft/s, and estimated discharge was 760 ft^3/s (Table 1).

DISCUSSION

Considerations in selecting final weir sites would be upriver distance to the site from the river mouth and boat traffic or local river usages (subsistence fishing areas, recreation). Sites located low in a drainage will allow for enumeration of all returning species. Higher drainage located sites may have some spawning occurring below enumeration sites and additional studies would be needed to estimate the amount of spawning downriver and in lower tributaries. Also, management decisions concerning fishery openings and closures rely on timely passage rates or other abundance estimators, so enumeration sites closer to the river mouth would be preferable if favorable site conditions exist. Of the four 2001 very good rated sites, distances from the river's mouth ranged from 9 km on the Sinuk River to 32 km on the Tubutulik River, and estimated weir materials costs FOB Nome ranged from $25,720 at Kwiniuk to $52,280 at Tubutulik. Additionally, $41,000 in labor and other fixed costs, and transportation costs to the selected site would be needed per weir.

Although Pilgrim River has the largest sockeye salmon escapement in the area, it drains into Port Clarence District. There are no commercial salmon fisheries in Port Clarence District and currently no subsistence closures are in effect seasonally nor reporting of harvests required. In the Pilgrim River drainage a subsistence fishing permit is required and fishers are required to report harvests. Therefore the Pilgrim River weir is not expected to be used for any inseason management decisions, but to gather accurate escapement data for all salmon species except pink salmon *O. gorbuscha* and representative ASL data on sockeye, chum, and coho salmon escapements. However, subsistence fishing restrictions or closures would be implemented if runs were deemed inadequate. A counting tower has been operational some years, but has had little success and counts have been unreliable.

Subsistence fishing pressure has increased in Port Clarence during the last five years (Magdanz et al. 2003), and Pilgrim River can be accessed from Nome by the road system and therefore fishing effort also appears to be increasing on this river. Increases are likely caused by the continuing fishing restrictions in the Nome Subdistrict. Accurate escapement data is needed to assess the increase and determine if sufficient sockeye salmon spawning stocks are reaching Salmon Lake where rehabilitation work has been conducted, and to monitor chum salmon escapements for declines as have been recorded in the Nome Subdistrict (1) during the last decade. Salmon Lake is at the headwaters of Pilgrim River, and is where a five-year nutrient enrichment program was done to increase the forage base for rearing juvenile sockeye salmon.

CONCLUSION

Although Sinuk River was recommended as the preferred location for the first resistance-board weir project in Norton Sound in 2001, it was later dropped in favor of Pilgrim River because of low numbers of returning salmon in this drainage and very little documented harvest occurs.

Pilgrim River was recommended as the second river to convert to weir enumeration because of favorable survey ratings, limited escapement data, the largest sockeye salmon returns in the area, and the ongoing restoration efforts that have been done at Salmon Lake. Almost all sockeye salmon in the drainage would be enumerated through the weir at this site. Additional studies or aerial surveys would need to be conducted to document fish not counted because an unknown number (at this time) of pink and some chum salmon spawn below the weir site. Stability of the left bank (facing downstream) at this site will require vigilance by on site crew personnel during high water events that normally occur in mid August after heavy rains. Additional sandbagging or erosion control fabrics may have to be placed along this bank during a flood event to minimize scouring. Chum and sockeye salmon runs should be over by the end of August while coho salmon would just be starting to run.

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Table 1. Hydrologic and substrate data by river and site location for resistance-board weirs from surveys in Norton Sound and Port Clarence, including site ratings and costs.

River [a]	Site	Date	Location [b]	Description	Width (ft)	Depth [c] (ft)	Velocity [d] (ft sec^{-1})	Maximum [e] flow (ft sec^{-1})	Discharge [f] (ft^3 sec^{-1})	Substrate	Weir Rating	Cost [g]
Unalakleet	1	7/2/01	63 53.32' N 160 29.14' W	River Mile 14	300	3 to 4	3 to 4			Gravel with small cobble	Good	$55,000
Unalakleet	2	7/2/01	63 52.55' N 160 36.81' W	Sarren's Camp	400	2 to 4.5	2 to 3.5			Small gravel, soft in areas	Poor	$71,000
Unalakleet	3	7/22/02	63 23.21' N 160 29.21' W		325	1.5 to 2.5	1.9 to 2.9	6.7	979		Good	$59,000
North	1	7/2/01	63 53.77' N 160 36.77' W	Martin's Camp	148	1.7 - 2.3	2.7 - 3.8	7.9	794	Cobble & hard packed sand	Good	$30,680
North	2	7/2/01	63 53' N 160 39' W	Current Tower Site	150	3	2 to 3			Gravel, soft in areas	Fair	$31,000
Tubutulik	1	7/3/01	64 50.43' N 162 02.43' W	1 mile upriver from old tower	250	3 to 4.5	4			Sm & med cobble sand & gravel	Fair	$47,000
Tubutulik	2	7/3/01	64 50.66' N 162 02.87' W	River Mile 18	270	3 to 4.5	4			Sm & med cobble	Good	$50,200
Tubutulik	3	7/3/01	64 50.86' N 162 06.82' W	River Mile 20	283	2.7 - 3.9	3.3 - 4.2	13.4	2,663	Sm, med & large cobble	Very Good	$52,280
Kwiniuk	1	7/4/01	64 46.70' N 162 04.62' W	River Mile 12	117	2.5 - 3.0	3.2 - 4.3	11.9	1,101	Sm & med cobble sand & gravel	Very Good	$25,720
Nome	1	7/5/01	64 29.81' N 165 13.13' W	Present Weir Site	180	2.9 - 3.9	1.9 - 2.8	10.6	1,005	Sm & med cobble sand & gravel	Poor	$35,800
Nome	2	7/5/01	64 32.97' N 165 12.91' W	Near Osborn Creek	150	2.5	3 to 4			Med & large gravel	Poor	$31,000
Snake	1	7/6/01	64 32.88' N 165 31.09' W		120	2 to 3	2 to 3			Small gravel	Poor	$26,200
Snake	2	7/6/01	64 34.38' N 165 29.96' W	3/4 mile upriver from bridge	126	1.7 - 2.3	1.9 - 3.2	7.0	473	Hard packed gravel	Fair	$27,160
Snake	3	7/6/01	64 31.65' N 165 30.81' W	Tower Site	100	3 to 4	2			Sand	Poor	$23,000
Snake	4	7/6/01	64 31.18' N 165 28.74' W		150	2 to 4				Sand	Poor	$31,000

-Continued-

Table 1. Continued (page 2 of 2).

River [a]	Site	Date	Location [b]	Description	Width (ft)	Depth [c] (ft)	Velocity [d] (ft sec^{-1})	Maximum [e] flow (ft sec^{-1})	Discharge [f] (ft^3 sec^{-1})	Substrate	Weir Rating	Cost [g]
Eldorado	1	7/6/01	64 34.41' N 164 56.24' W	Tower Site	111	2.2 - 3.1	1.9 - 2.8	7.5	528	Small gravel & sand	Poor	$24,760
Sinuk	1	7/7/01	64 40.42' N 166 00.50' W		240	2 to 3.5	3.5			Sm & med cobble	Fair	$45,400
Sinuk	2	7/7/01	64 36.57' N 166 12.28' W	Above tidal zone	400	4				Sand & gravel	Poor	$71,000
Sinuk	3	7/7/01	64 38.41' N 166 13.17' W	5.5 mile from mouth	237	3 to 4	3.5			Cobble & gravel	Very Good	$44,920
Niukluk	1	7/8/01	64 49.38' N 163 28.34' W	Lower river	300	6	2			Small cobble, sand & gravel	Poor	$55,000
Niukluk	2	7/8/01	64 49.11' N 163 28.97' W	Mosquito Bar	500	2 to 4.5	2			Large gravel & sand	Poor	$87,000
Niukluk	3	7/8/01	64 49.45' N 163 30.10' W	1/2 mile upriver of tower site	278	2.3 - 3.3	2.9 - 4.3	13.5	2,438	Med & large gravel & sand	Very Good	$51,480
Pilgrim	1	7/10/01	65 06.23' N 164 50.01' W		200	3 to 4.5	2.5			Med gravel & sand	Fair/Good	$39,000
Pilgrim	2	7/10/01	65 06.17' N 164 49.45' W	6 miles above Hot Springs	219	2.3 - 3.2	2.1 - 3.1	10.1	1,305	Med gravel & sand	Good	$42,040
Shaktoolik	1	7/23/02	64 22.18' N 160 23.37' W		200	2.3 - 3.2	1.5 - 2.6	8.5	760	Hard packed gravel	Good	$39,000
Shaktoolik	2	7/23/02	64 22.06' N 161 22.40' W		130	2.1 - 3.0	2.4 - 3.5	10.1	748	Mixed gravel	Fair/Good	$27,800

[a] If site looked unfavorable then the full survey including hydrologic measurements were not done, so some values are missing.

[b] Location was determined from a hand held Global Positioning System (GPS) that was accurate to within 100 meters.

[c] Depth range is the average (first number) and maximum (last number) depth recorded across the site on the date measured.

[d] Velocity range is the average (first number) and maximum (last number) velocity recorded across the site on the date measured.

[e] Maximum flow is the maximum point flow, calculated by station depth x velocity, from all stations at the site.

[f] Discharge is for date measured and not representative of high to low ranges expected to be encountered throughout normal weir operational season.

[g] Costs are for weir materials only including live box trap and bulkheads, and do not include set up, personnel or transportation costs.

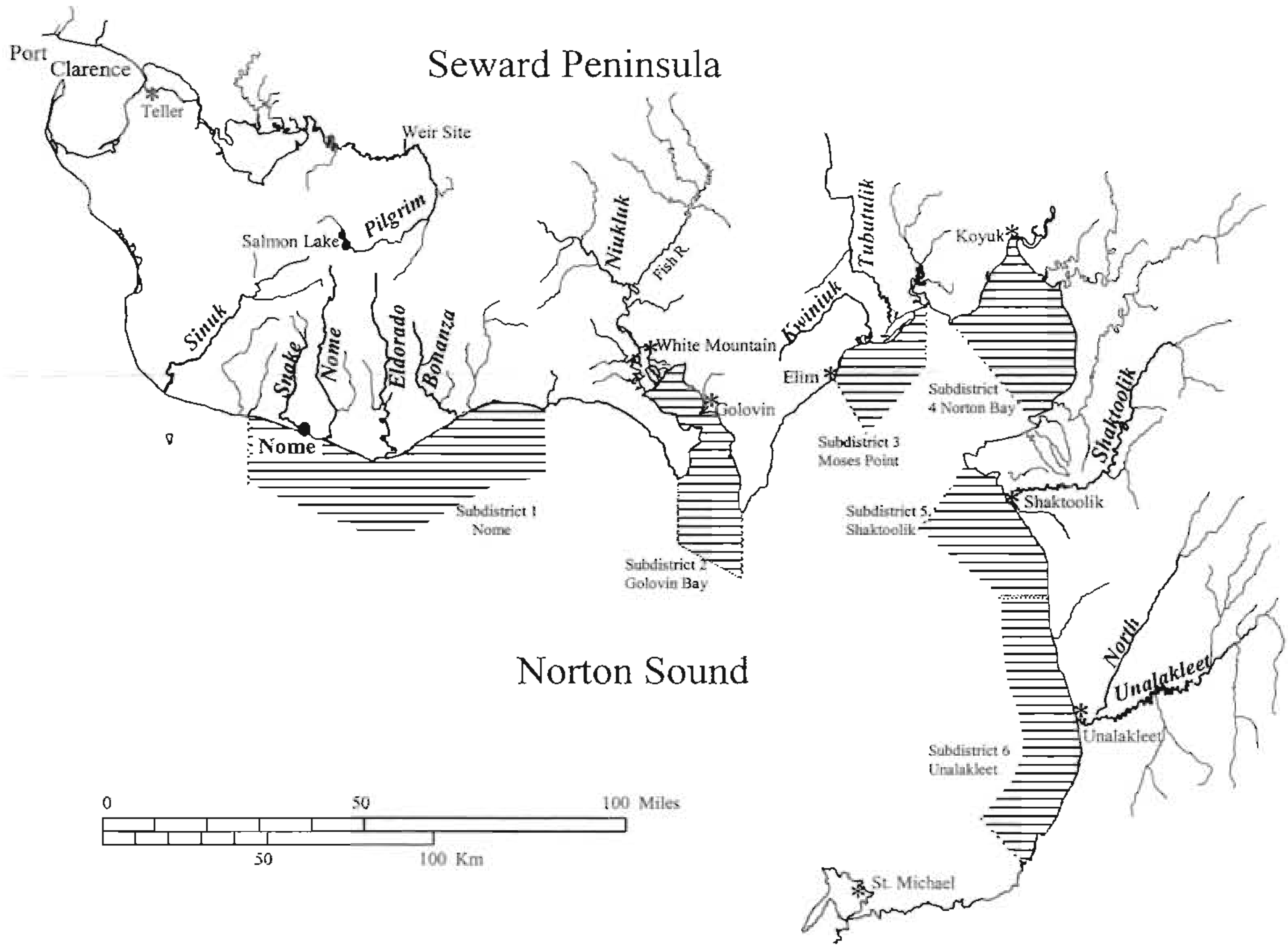

Figure 1. Southern Seward Peninsula Area map showing Norton Sound commercial fishery management subdistricts and Port Clarence, and surveyed rivers (in *Italics*) for possible resistance-board weir sites to enumerate salmon returns.